

**BOX PATENT
APPLICATION**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: L. Chen Attorney Docket No.: SEMT117581
Application No.: FILE CONCURRENTLY Group Art Unit: --
HEREWITH
Filed: CONCURRENTLY Examiner: --
HEREWITH
Title: APPARATUS AND METHOD FOR ELECTROLYTICALLY DEPOSITING
COPPER ON A SEMICONDUCTOR WORKPIECE

PRELIMINARY AMENDMENT

Seattle, Washington 98101

June 20, 2001

TO THE COMMISSIONER FOR PATENTS:

In the Specification:

Please amend the specification at page 1, CROSS-REFERENCE TO RELATED APPLICATIONS section, by deleting the first paragraph thereunder reading "Not Applicable" and replace it with the following new paragraph:

This application is a continuation of U.S. Application Serial No. 09/387,033 filed August 31, 1999, which is a continuation of International Application Serial No. PCT/US99/06306 designating the United States filed March 22, 1999, which is a continuation-in-part of U.S. Application Serial No. 09/045,245 filed March 20, 1998, and claims the benefit of U.S. Provisional Application Serial No. 60/085,675 filed May 15, 1998, priority from the filing dates of which are hereby claimed under 35 USC Sections 120 and 119(e), and the disclosures of which are hereby incorporated in their entirety.

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In the Claims:

Please cancel Claims 1-59.

Please add new Claims 60-86 as follows:

60. (New) A process for applying a metal structure to a workpiece comprising:

providing a first electroplating bath including a source of metal ions as a principal metal species to be deposited during subsequent electroplating, boric acid, and a metal ion complexing agent;

providing a workpiece on which one or more microelectronic devices are to be formed;

exposing at least one surface of the workpiece to the first electroplating bath;

applying electroplating power between the at least one surface of the workpiece and an electrode disposed in electrical contact with the first electroplating bath to electroplate the principal metal species onto the at least one surface of the workpiece in an electrolytic first deposition process, wherein power is applied during at least a portion of the first deposition process for a workpiece surface current density of between 1.0 mA/cm² and 5.0 mA/cm².

61. (New) The process of Claim 60, wherein power is applied during at least a portion of the first deposition process at a workpiece surface current density of about 2.0 mA/cm².

62. (New) The process of Claim 60, wherein power is applied at a workpiece surface current density of between 1.0 mA/cm² and 5.0 mA/cm² over a time period of between 1.0 and 5.0 minutes.

63. (New) The process of Claim 60, wherein power is applied in periodic pulses during deposition.

64. (New) The process of Claim 63, wherein power is applied in forward pulses having a period of about 2 msec at a 50% duty cycle.

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65. (New) The process of Claim 60, further comprising depositing additional metal of the same principal metal species onto the metal deposited in the first deposition process using a second deposition process that is different than the first electrolytic deposition process.

66. (New) The process of Claim 65, wherein the second deposition process occurs in an acidic electrolytic bath.

67. (New) The process of Claim 65, wherein metal is deposited in the second deposition process at a higher rate than in the first deposition process.

68. (New) The process of Claim 60, wherein the metal deposited is copper.

69. (New) The process of Claim 67, wherein the source of metal ions comprises copper sulfate included at a level of 0.03 to 0.25 M.

70. (New) The process of Claim 60, wherein the first electroplating bath comprises an alkaline bath.

71. (New) The process of Claim 70, wherein the alkaline bath has a pH of at least 9.0.

72. (New) The process of Claim 71, wherein the alkaline bath is pH adjusted with an alkaline agent selected from the group consisting of potassium hydroxide, ammonium hydroxide, tetramethylammonium hydroxide and sodium hydroxide.

73. (New) The process of Claim 60, wherein the first electroplating bath includes a conformality increasing agent.

74. (New) The process of Claim 73, wherein the conformality increasing agent comprises ethylene glycol.

75. (New) The process of Claim 74, further comprising depositing a barrier layer on the surface of the workpiece before the first deposition process.

76. (New) The process of Claim 75, wherein metal is plated directly onto the barrier layer in the first deposition process.

77. (New) The process of Claim 75, further comprising depositing an ultra-thin seed layer of metal onto the barrier layer before the first deposition process.

78. (New) The process of Claim 60, further comprising depositing an ultra-thin seed layer of metal onto the barrier layer before the first deposition process.

79. (New) The process of Claim 60, wherein the complexing agent is selected from the group consisting of ED, EDTA, and a polycarboxylic acid.

80. (New) The process of Claim 79, wherein the complexing agent is citric acid.

81. (New) The process of Claim 60, wherein the source of metal ions comprises copper sulfate, and the complexing agent comprises ED, further comprising tetramethylammonium hydroxide in an amount sufficient to adjust the pH of the solution to at least 9.0.

82. (New) A process for applying a metal structure to a workpiece comprising:

providing a first electroplating bath including a source of metal ions as a principal metal species to be deposited during subsequent electroplating, a metal ion complexing agent and an alkaline agent in an amount sufficient to adjust the pH of the bath to at least 9.0;

providing a workpiece on which one or more microelectronic devices are to be formed;

exposing at least one surface of the workpiece to the first electroplating bath;

applying electroplating power between the at least one surface of the workpiece and an electrode disposed in electrical contact with the first electroplating bath to electroplate the principal metal species onto the at least one surface of the workpiece in an electrolytic first deposition process, wherein power is applied during at least a portion of the first deposition process for a workpiece surface current density of between 1.0 mA/cm² and 5.0 mA/cm².

83. (New) A process for applying a metal structure to a workpiece comprising:
providing a first electroplating bath including a source of metal ions as a principal metal species to be deposited during subsequent electroplating, boric acid, and a metal ion complexing agent;
providing a workpiece on which one or more microelectronic devices are to be formed;
exposing at least one surface of the workpiece to the first electroplating bath;
applying electroplating power between the at least one surface of the workpiece and an electrode disposed in electrical contact with the first electroplating bath to electroplate the principal metal species onto the at least one surface of the workpiece in an electrolytic first deposition process, wherein power is applied during at least a portion of the first deposition process in periodic pulses.

84. (New) The process of Claim 83, wherein power is applied in forward pulses having a period of about 2 msec at a 50% duty cycle.

85. (New) The process of Claim 84, wherein pulsed power is applied for a period of 1.0 to 5.0 minutes.

86. (New) A process for applying a copper structure to a workpiece comprising:
providing a workpiece on which one or more microelectronic devices are to be formed;
depositing an ultra-thin seed layer of copper onto a surface of the workpiece;
providing a first electroplating bath including copper as a source of metal ions as a principal metal species to be deposited during subsequent electroplating and an alkaline agent in an amount sufficient to adjust the pH of the bath to at least 9.0;
exposing the surface of the workpiece to the first electroplating bath;
applying electroplating power between the surface of the workpiece and an electrode disposed in electrical contact with the first electroplating bath to electroplate the principal metal


[illegible]

REMARKS

Please enter the above amendment prior to examination.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE JUNE 20, 2001

In the Specification:

A new paragraph has been added on page 1 in the Cross Reference to Related Applications section in place of the existing paragraph.

In the Claims:

Claims 1-59 have been cancelled.

Claims 60-86 have been added.

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